XIX. *Additional Experiments and Obſervations relating to the Principle of Acidity, the Decompoſition of Water, and Phlogiſton. By* Joſeph Prieſtley, *LL.D. F. R. S. With Letters to him on the Subject, by Dr.* Withering, *and* James Keir, *Eſq.*

Read May 1, 1788.

WHEN I wrote the Paper, which the Society has done me the honour to order to be printed in their Tranſactions, I had found that the decompoſition of dephlogiſticated and inflammable air, by means of the electric ſpark, produced an *acid liquor*, which Dr. WITHERING found to be the *nitrous*; though I ſhould have obſerved, that he expreſſed ſome doubt whether the liquor did not alſo contain ſome other acid beſides the nitrous.

I have ſince that time been deſirous to aſcertain the *quantity of acid* producible from a given quantity of air; and with this view I gave Mr. KEIR as much of the liquor as I had collected from the decompoſition of about five hundred ounce meaſures of dephlogiſticated air, and the uſual proportion of inflammable air mixed with it. The liquor, he informed me, was 442 grains, of the ſpecific gravity of 1022 (that of water being 1000) and that it contained as much acid as was equivalent to 12.54 grains of concentrated acid of vitriol; which quantity of vitriolic acid is capable of ſaturating as much vegetable fixed alkali as is contained in 22½ grains of dry nitre,

5

or about 23¼ grains of nitre cryſtallized in mean temperature. The ſediment of the ſame liquor he alſo ſuppoſed to contain, at leaſt, as much acid as the liquor itſelf.

That this ſediment contains much acid, ſeems evident from this circumſtance, that, when it is firſt formed, it often emits ſmall bubbles, which riſe to the ſurface of the liquor, and continues to do ſo a conſiderable time. This was more particularly the caſe with the ſediment which I had from the tinned iron tubes. Theſe ſmall bubbles, I imagine, conſiſt of nitrous air (formed from the ſuperabundant acid vapour adhering to the metal and the water in the liquor) becauſe when a phial, half filled with this liquor, had ſtood about a week, the air on the ſurface of it inſtantly, and repeatedly, extinguiſhed a piece of lighted wood that was dipped into it.

From the preceding *data*, given me by Mr. KEIR (and making allowance for the indefinite quantity of water contained in the concentrated acid of vitriol) I am inclined to think, that not much more than one-twentieth part of dephlogiſticated air is the acidifying principle, and that nineteen parts are water.

This, I would however obſerve, relates to air fully ſaturated with water, in conſequence of its having been kept in jars ſtanding in water, ſo that I think it poſſible that the water in the drieſt dephlogiſticated air may not amount to more than nine-tenths of its weight. But I have not aſcertained, by any experiment, how much water any of the kinds of air are capable of holding in a diffuſed ſtate, without being any neceſſary part of their conſtitution.

Though Mr. KEIR found the greateſt part of the acid in the liquor with which I furniſhed him to be the *nitrous*, there were evident ſigns of its containing a ſmall portion of *marine* acid,

acid, by its making a precipitation with a ſolution of ſilver in nitrous acid. But this mixture of marine acid, he obſerves, is conſtantly found to accompany the production of nitre in the operations of nature. Whether the different ſubſtances from which the dephlogiſticated air was extracted made any difference in this caſe, I cannot tell; but that which I gave Dr. WITHERING was from minium, and that which Mr. KEIR examined was from manganeſe.

In the notes which I took of the firſt production of this liquor I termed it *blue*, and Dr. WITHERING alſo calls it blue, and once a *greeniſh blue*; but that which I gave Mr. KEIR, and all that I have got ſince, is a decided and deep *green*, which Mr. KEIR thinks to be owing to the phlogiſtication of the nitrous acid.

Thoſe philoſophers who are unwilling to admit the doctrine of phlogiſton, will perhaps ſay, that, in thoſe experiments in which a calx is revived by means of inflammable air, this air joins the dephlogiſticated air that was in the calx; and that, in conſequence of this, the metal, being freed from a foreign ſubſtance, reſumes its proper form and qualities, without having received any addition whatever.

But ſince it appeared in the preceding experiments, in which inflammable air was procured by means of ſteam, that the *metal* did not become a *calx*, except in conſequence of parting with inflammable air (or rather with ſomething which, when united to water, is inflammable air) it cannot be ſuppoſed to recover its metallic form without re-imbibing the ſame thing that it had loſt, which thing may be termed *phlogiſton*.

Conſequently, inflammable air being (in the opinion of thoſe who do not admit the doctrine of phlogiſton) the ſame

thing with the ſubſtance from which it was procured, only volatilized, and united to water, it will follow, that any ſubſtance imbibing inflammable air muſt become compounded with that other ſubſtance from which the inflammable air was produced; and therefore, all the inferences recited in the former Paper, which tend to eſtabliſh the doctrine of phlogiſton, muſt be admitted.

It will be aſked, what becomes of the dephlogiſticated air which is certainly expelled from red precipitate when it is heated in inflammable air, and converted into running mercury, if the inflammable air enters into the calx, in order to its becoming a metal? I anſwer, that it unites with a part of the inflammable air, and forms nitrous acid; for the water that is collected in this proceſs is ſtrongly acid, as appears by its turning the juice of turnſole red; but the quantity is ſo ſmall, that it will hardly be poſſible to aſcertain what acid it is. Analogy, however, decides clearly in favour of the nitrous.

It may be ſuppoſed, that in this experiment with *red precipitate*, the acid was that which had not been ſufficiently expelled from that ſubſtance in the proceſs by which it is made. But the reſult was the very ſame when I uſed *precipitate per ſe*; and on this occaſion I uſed a portion of that which I procured from M. CADET in Paris, of which mention is made in the ſecond Volume of my Experiments, p. 36.

On the other hand, that which is expelled from finery cinder, when it is heated in contact with inflammable air (and thereby becomes *iron)* is *pure water*, without any acid. This I found to be the caſe even when the inflammable air had been got from iron by oil of vitriol. Does not this prove that the

iron had imbibed what was properly *water*, and not any one constituent part of water only?

That water enters into the constitution of every kind of air I supposed, because it certainly does into that of *inflammable*, *fixed*, and *dephlogisticated* air, and because none of them can be produced except by processes in which water either certainly is, or may be well supposed to be, present. That *nitrous* air also contains water, I have lately found from the iron that is heated in it becoming a proper finery cinder.

At the publication of my last Volume of Experiments, I had found, that iron heated in nitrous air acquired weight, and that what remained of the air was phlogisticated air. Having since that time repeated this experiment, and afterwards heated the iron, which was by this means increased in weight, in inflammable air, the iron lost its additional weight, and water was copiously produced, as in the same process with finery cinder, or, as I sometimes call it, scale of iron.

As nitrous air may be deprived of its water, and become phlogisticated air by heating iron in it, I find that it undergoes the same change by being repeatedly transmitted through hot porous earthen tubes, through which I some time ago discovered that vapour will pass one way, while the air contiguous to the heated tube will pass the other.

I first tried this process with turnings of iron in the tube, by which means the iron was readily converted into finery cinder; but afterwards I found that the same change was produced in the nitrous air by the hot tube only. The two bladders which I made use of in this experiment (and by the alternate pressure of which I made the air contained in them pass through the hot tube) became *red*, just as any bladder does that is filled with nitrous air, and then exposed to the influ-

ence of the atmoſphere till it becomes phlogiſticated air, as may be ſeen in my former experiments. In this manner I now always treat the bladders in which I make experiments on air. It prevents them from putrefying, and gives them a firmneſs of texture ſimilar to tanning.

That nitrous air contains water, and that this water can contribute to the formation of fixed air, is evident from the following experiment. I heated five grains of charcoal of copper in eight-ounce meaſures of nitrous air, till it was increaſed to ten-ounce meaſures, and the charcoal had loſt one grain. Examining the air, I found about one-fifth of it to be fixed air, and the remainder phlogiſticated. It ſeems, therefore, that nitrous air conſiſts of water, and ſomething that may be called the baſis of nitrous acid, or that ſubſtance which, when united to dephlogiſticated air, will make nitrous acid; and this ſeems to be pure phlogiſton, ſince it is found, as the preceding experiments ſhew, in the pureſt inflammable air. May we not hence infer, that the nitrous is the ſimpleſt of all the acids, and perhaps the baſis of all the reſt?

It is evident, that more water than enters into the compoſition of nitrous air is neceſſary for the change of it into what I have called *dephlogiſticated nitrous air*, becauſe the contact of iron will not, without water, produce that change in it.

Though fixed air, as I have ſhewn, contains water as well as nitrous air, it cannot be deprived of it, and be decompoſed, by the ſame means; for I have heated iron in it by a burning lens, and have alſo made it paſs repeatedly through a hot earthen tube containing turnings of iron, without producing any change in it.

In the former Paper I ſaid, that manganeſe of itſelf gives only the pureſt dephlogiſticated air by heat; but I have now

a quantity

a quantity which, after giving pure air with a moderate heat, gives air that is more than half fixed air with a greater degree of heat. It is evident, as I have obferved before, that there are very different kinds of manganefe.

In thefe Papers I have fuppofed, with M. LAVOISIER and others, that the *principle of acidity* is in the dephlogifticated air only; but as the acid is always formed by the union of this air and the inflammable, it may, perhaps, with equal probability be fuppofed to be in either of them, or to be a compound of them both.

Mr. WATT defires me to mention it as his conjecture, that the nitrous acid is contained in the inflammable air as the acid of vitriol is in fulphur, the phofphoric in phofphorus, &c.; and that the dephlogifticated air does nothing more than develope the acid. Mr. KEIR, who was led to expect that an acid *muft* be the refult of the union of dephlogifticated and inflammable air, becaufe fome acid is always the confequence of its union with other inflammable fubftances, thinks that both may be neceffary ingredients in it. Farther experiments may throw more light on the fubject.

TO THE REV. DR. PRIESTLEY.

DEAR SIR,

I at length fubmit to your confideration the trials which I made upon the liquors you produced, by the firing of *dephlogifticated* and *inflammable air* in clofe veffels; and if you think

think proper you may tranſmit them to the Royal Society, by way of Appendix to your own Paper upon that Subject.

§ I.

Dec. 25, 1787. LIQUOR produced by burning, in a cloſe *copper* veſſel, *inflammable air* got from IRON by means of the ſteam of water, and *dephlogiſticated air*, expelled by heat only, from MINIUM.

This liquor was blue, and contained a reddiſh brown ſediment.

Exp. 1. *Terra ponderoſa lime water*,

2. *Common lime water*, and

3. *Cauſtic fixed alkali*, cauſed a greeniſh precipitation.

4. *Cauſtic volatile alkali* produced a beautiful deep blue precipitate, which was wholly re-diſſolved by the addition of more volatile alkali.

5. *Phlogiſticated alkali* gave a reddiſh brown precipitate.

6. *Nitre of lead*, no change.

7. *Nitre of ſilver*, a bluiſh precipitate.

8. *Litmus*, its colour firſt turned red, then curdled, and at length nearly deſtroyed.

9. The *filtering paper*, employed to ſeparate the ſediment, was a ſlow burning touch-paper.

§ II.

Dec. 30. LIQUOR produced, by burning in a cloſe *copper* veſſel, *inflammable air*, obtained as in § I. and *dephlogiſticated air*, expelled by heat only, from MANGANESE. This liquor was blue, and contained a reddiſh-brown ſediment.

Exp. 1—9. Similar to thoſe in § I.; and the reſults being in all points the ſame, I determined to mix the liquids together,

ther, the quantities being ſmall, and ſubmit them to further examination.

§ III.

Exp. 1. The united liquids being neutralized by the addition of *cauſtic vegetable alkali*, a beautiful green precipitate ſubſided.

2. This *precipitate* diſſolved entirely in cauſtic volatile alkali, changing to a beautiful blue.

3. The ſuper-natant liquid being ſlowly evaporated to dryneſs, the liquor that eſcaped during this proceſs was nothing but *pure water*.

4. The imperfectly cryſtallized reſiduum (3) efferveſced upon the addition of concentrated vitriolic acid, and being ſubmitted to diſtillation, on the firſt application of heat, an orange-coloured vapour aroſe, which was condenſed in a receiver previouſly wetted with pure water.

5. The diſtilled liquor (4) had the ſmell and the taſte of *nitrous acid*, which inſtantly changed the blue of litmus, and that of violet paper to a red; and it acted upon ſilver.

6. *Terra ponderoſa lime water*, added to it, occaſioned no precipitation.

7. Saturated with vegetable alkali it converted cap paper into touch paper, and formed, upon a ſlow evaporation, cryſtals ſimilar to thoſe of nitre.

§ IV.

Jan. 21, 1788. LIQUOR produced by burning *inflammable air*, obtained as before; and *dephlogiſticated air* from *mercurius precip. ruber*, in a cloſe *tinned iron* veſſel.

This

This liquor was nearly colourlefs, but contained a large quantity of a light brown fediment.

Exp. 1. 2. 3. 4. 5. 8. 9. Similar to thofe of § 1. and 11. except the different colour of the precipitates, and that made by the phlogifticated alkali being a fine blue.

10. The liquor faturated with vegetable alkali being flowly evaporated to drynefs, and the precipitates mixed with the brown fediment being put into a retort, fome concentrated vitriolic acid was added, and heat was applied. A *very* faint fmell of nitrous acid arofe, but no vifible red vapour; nor did any thing diftil into the receiver until the heat was very confiderable.

11. The liquor then diftilled was evidently acid; but this acid was wholly precipitated by terra ponderofa lime water.

§ V.

Feb. 19. Having now received a larger quantity of the *liquor* and fediment, produced as § 1. *viz.* 329 grains of the bluifh green liquor, and 12 grains of the reddifh brown fediment, I proceeded to repeat the experiments, but the refults correfponding with the former ones, I need only mention, that the liquor changed litmus red, and coagulated it; that with phlogifticated alkali it gave a brownifh red, and with cauftic vegetable alkali a blue precipitate; that after faturation with the vegetable alkali, both the dried falt and the fediment being fubmitted to diftillation with the addition of concentrated vitriolic acid, an orange-coloured vapour inftantly arofe, and the peculiar fmell of nitrous acid was ftrongly perceived. The diftilled

liquor,

liquor, beſides having the taſte of nitrous acid, diſſolved ſilver; and when neutralized by vegetable alkali and ſlowly evaporated, afforded well-formed cryſtals of common nitre.

Theſe, Sir, are all the trials I have made with the liquors produced in your experiments. They pretty clearly prove the acid generated to be the ſame, whether the dephlogiſticated air was procured from red precipitate of mercury, from minium, or from manganeſe, and that this acid is the *nitrous acid*. It is not quite ſo clear why the liquor and ſediment in § IV. gave no ſtronger marks of the preſence of nitrous acid; but it is evident, that the acid had united itſelf to the iron, if not to the tin, of the veſſel employed: and I find, that when nitrous acid is fully ſaturated with iron by being boiled with it, and fixed alkali is added, this mixture ſubmitted to diſtillation, with the addition of concentrated vitriolic acid, yields no red vapours, and very little ſmell of nitrous acid.

I remain, &c.

W. WITHERING.

Birmingham,
February 22, 1788.

TO THE REV. DR. PRIESTLEY.

DEAR SIR,

I HAVE examined the green liquor which I received from you, with a view to determine the two points you wiſhed prin-

cipally to know, namely, the *quantity* and the *kind* of the contained acid.

The quantity of the green liquor was 442 grains, and its ſpecific gravity was to that of water as 1022 to 1000. When the green liquor was poured out of the phial, there remained at the bottom 72 grains of a brown powder, which upon examination was found to be a calx of copper, ſoluble in acids, but not in water.

The colour of the liquor ſhewed that it was a ſolution of copper. However, it gave no cupreous precipitation to poliſhed ſteel, till a few drops of acid had been added. This circumſtance ſeemed to ſhew the perfect ſaturation of the acid of the green liquor with the copper; and this complete ſaturation was further evinced by the very ſmall alteration of colour which litmus ſuffered on being mixed with this liquor. This teſt did indeed ſeem to acquire a little tendency to redneſs, but the effect was ſo minute as not to deſerve conſideration, and might probably be owing to ſome ſlight phlogiſtication, as it is called, of the acid contained, rather than to its ſuperabundance.

Upon evaporating the green liquor by expoſure to air, without the application of heat, no cryſtals were formed, but a dry green powder, inſoluble in water, but ſoluble in acids. You had before acquainted me with this fact. As ſolutions of copper in the nitrous acid are known to yield deliqueſcent cryſtals, and as no cryſtallization happened in this inſtance, although the acid was evidently nitrous, I was deſirous of diſcovering the cauſe of this difference between this liquor and common ſolutions of copper in the nitrous acid. Upon making ſome trials with this view, I found that there were three periods or ſtages to be diſtinguiſhed in the combination of copper with the nitrous acid. The firſt period is when the acid is ſuper-

 abundant,

abundant, and deliqueſcent cryſtals formed. The ſecond period is when the acid has been completely ſaturated, or perhaps ſuperſaturated, by repeated and alternate evaporation to dryneſs, and re-diſſolution in water, and then no cryſtals but a green powder is formed. The third period is when, by a further evaporation of acid and increaſe of heat, the green powder is changed into a brown or black calx. The complete ſaturation of the green liquor ſeems then to be the cauſe of the formation of the green powder on evaporation, inſtead of deliqueſcent cryſtals; and the production of the brown calx may be ſuppoſed to be either the reſult of a calcination of a part of the ſolution of copper which may have taken place in conſequence of the great heat excited by the inflammation of the two airs; or to have been formed by the action of the heated dephlogiſticated air on the copper.

In order to find the quantity of acid that was contained in the green liquor, I added, by ſlow degrees, to 100 grains of this liquor, a ſolution of mild fixed alkali, till no more precipitation took place, taking great care to ceaſe adding alkali as ſoon as the copper ceaſed to precipitate, to prevent a re-diſſolution of the precipitated metal. Upon examining how much of this alkaline ſolution was required to ſaturate a given quantity of oil of vitriol of the common ſpecific gravity, *viz.* to water as 1844 to 1000, I found that the 100 grains of green liquor required for its precipitation as much alkali as would ſaturate 2,837 grains of the above-mentioned acid of vitriol. And as the whole quantity of green liquor was 442 grains, its precipitation would require as much alkali as would be capable of ſaturating 12,54 grains of the concentrated vitriolic acid.

This quantity of vitriolic acid is capable of ſaturating as much vegetable fixed alkali, as is contained in 22½ grains of dry

nitre, or about $23\frac{1}{4}$ grains of nitre cryſtallized in mean temperature *.

The difficulty of finding even an approximation of the quantity of acid, or of air expended in forming the brown calx, muſt be very great; and this circumſtance ſhews the diſadvantage of uſing metallic veſſels, although in other reſpects more commodious for your large experiments than thoſe of glaſs. I think it is probable, that the quantity of acid expended in this manner is as much or more than the quantity retained in the ſolution; but I am ſorry I am not able to give you any grounds for a true determination. However, the experiment which I made with the calx was as follows. I diſſolved it in vitriolic acid, and having ſaturated with alkali the ſuperfluous acid, I precipitated the ſolution by a fixed alkali of known ſtrength, and I found that the quantity of alkali requiſite for this precipitation was as much as would ſaturate ten grains of the oil of vitriol before mentioned. This quantity of vitriolic acid is ſo much leſs than I ſhould expect, that I regret I have not an opportunity of repeating the experiment.

The next point to be determined is the *ſpecies* of acid that is contained in the green liquor. The acid produced in your former experiments of burning inflammable and dephlogiſticated airs was determined to be the nitrous; and every trial which I have made of this green liquor has convinced me, that the ſame acid is contained in it alſo. Upon adding to this liquor ſome vitriolic acid and diſtilled water, I obtained by

* I ſay the *mean temperature*, becauſe the proportion of water retained by ſalts varies very conſiderably, according to the temperature in which they are cryſtallized; the warmer the weather, the leſs water being retained. The conſideration of this fact ought to enter into the eſtimates of the proportions of the component parts of ſalts.

diſtillation a colourleſs acid liquor, which from the ſmell, the properties of diſſolving ſilver very readily, and of giving a deflagrating quality to paper ſoaked in this liquor when ſaturated with alkali, evidently manifeſted the preſence of the nitrous acid. But beſides the nitrous, which is undoubtedly the acid in greateſt abundance, I think I may venture to affirm the exiſtence alſo of the marine acid.

Upon adding to the green liquor a ſolution of ſilver in which the acid was ſuperabundant, the mixture became turbid; and when it was boiled, the minute particles collected and fell to the bottom in form of white flocks, which, on expoſure to light, became dark coloured, and were re-diſſolved by volatile alkali; all which appearances are indications of a luna cornea. Although theſe appearances left no doubt in my mind of the exiſtence of a marine acid, I am nevertheleſs much obliged to our ingenious philoſophical friend Mr. JOHNSON for reminding us, that Mr. CAVENDISH had alſo obſerved, in the acid produced in his experiment of paſſing the electric ſpark through a mixture of dephlogiſticated and phlogiſticated airs, a precipitation upon adding a ſolution of ſilver; from which, however, that moſt accurate philoſopher would not infer the preſence of marine acid, having diſcovered that the precipitation might be produced by the nitrous acid itſelf, when that acid is much phlogiſticated. The acid of the green liquor is in ſome degree phlogiſticated, as appears both from the ſmell which I perceived on adding the ſolution of ſilver, which, as I have mentioned, contained a ſuperabundant acid, and from the green colour of the liquor; for I have never been able to make any but blue or greeniſh-blue ſaturated ſolutions from copper and nitrous acid, although they ſometimes appear green from a ſuperabundant quantity of yellow acid, or from the yellow

fumes

fumes during the solution. By adding a solution of melted nitre to the blue solutions of copper either in the nitrous or vitriolic acids, the phlogisticated acid of the melted nitre immediately communicates a green colour. The marine acid tends more than the other acids to give a green colour; but I am inclined to impute the colour of your liquor principally to the phlogistication of the acid, because upon adding a very small portion of vitriolic, marine, or nitrous acid, the colour was immediately changed to a light blue. The solution of silver, being purposely acid, always produced this change of colour, and I therefore considered, that the phlogisticated acid was expelled in the operation, and could not affect the precipitation.

Experiments have taught me, that an exceedingly slight degree of that quality which is called the phlogistication of nitre, is sufficient to produce an alteration in the colour of solutions of copper, and that the colour will be changed when the degree of phlogistication is incapable of producing any precipitation of silver. Not only a solution of melted nitre will always change the colour of cupreous solutions, but even crystals of nitre, when mixed with the nitrous acid, and the mixture boiled to dryness upon copper, and re-dissolved in water, will give a green solution. If crystals of nitre be dissolved in a colourless solution of silver in nitrous acid, and this mixture added to a solution of copper in the same acid, the blue colour of the latter will be changed to a green, although neither the nitre nor solution of silver will separately have this effect, neither will nitre dissolved in a dilute nitrous acid. I do not know what degree of phlogistication may be required to precipitate silver, but I suppose it to be very great; at least it is certain, that the degree of phlogistication capable of giving a green

green colour to folutions of copper is infufficient to precipitate filver. Mr. CAVENDISH, when he relates the fact of the precipitation of filver, fpeaks only of nitre, *much* phlogifticated, poffeffing this property.

To obviate any fufpicion of the precipitation of filver being owing to the phlogiftication of the acid, I added to fome of the green liquor about an equal quantity of colourlefs nitrous acid and fome diftilled water, and I kept this mixture boiling half an hour, in order to difengage and expel any phlogifticated acid which it might contain. To the liquor, which remained perfectly pellucid, I added a folution of filver, upon which the precipitation immediately took place with all its ufual circumftances, and in as great a degree as before.

If, upon examining the acids which you or others may hereafter obtain by the inflammation of airs, a mixture of marine acid be conftantly found to accompany the production of the nitrous, the fact will be only analogous to all the other known productions of nitrous acid; in all which, either in the natural formation of nitre as in Spain and India, or in the nitre beds and walls made by art, a very large proportion of marine falts is conftantly obferved to accompany the nitre.

I fhall conclude my letter with mentioning a fact, which I obferved in making fome experiments to find the caufe of the formation of the green powder above-mentioned, and which, though not relative to the prefent fubject, may be thought not unworthy of communication. It is the *decompofition of common falt and feparation of its alkali by copper*. As I conceived the opinion that the formation of this green powder by evaporation of this green liquor was owing to the perfect faturation of the acid, among other modes of obtaining a perfectly faturated folution of copper, I fprinkled upon plates of copper ftrong folutions

of

of common ſalt and of ſal ammoniac. In a few days the ſal ammoniac was found to have converted the copper into a dry green calx; but the common ſalt acted more ſlowly upon the copper, and continued moiſt during ſeveral weeks. At length, however, at the end of two months, a dry green calx was formed, and I obſerved, that round the edges of the calx where it joined to the ſurface of the copper not acted upon, and where the liquor had laſt ſtood before it was dried, an efflorefcence had formed of mild mineral alkali, which ſeems to have been ſeparated from its acid by the action of the copper on the acid, and perhaps aided by the affinity of the alkali itſelf to fixed air.

The ſal ammoniac alſo had probably been decompoſed by the copper, but the volatility of its alkaline baſis, when diſengaged, had prevented its appearance.

Wiſhing you may long continue to add to the numerous and ſplendid liſt of diſcoveries with which you have already enriched natural philoſophy,

I am, &c.

JAMES KEIR.

March 26, 1788.